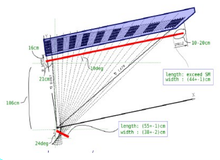
# The ECAL online software and the commissioning of the CMS detector

Pasquale Musella on behalf of the CMS ECAL Group
LIP Lisbon, Portugal
pasquale.musella@cern.ch

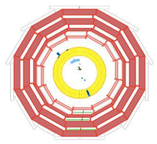
**2005** **2006** **2007** **2008** **ECAL Commissioning time line**

**Barrel construction and intercalibration with Cosmic Rays**



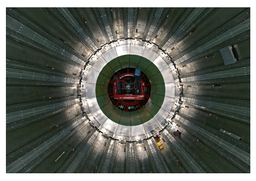
**Barrel Test beam**

**CMS Magnet Test and Cosmic Challenge**



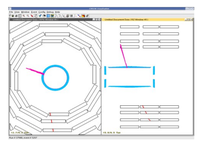
**Endcap Test beam**

**Barrel Installation and commissioning**



**Endcap construction and Installation**

**CMS Cosmic Rays commissioning and first LHC beam**



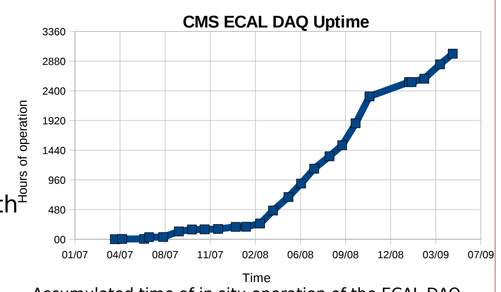
## Role and performances of the CMS ECAL Online Software in the detector commissioning

The Compact Muon Solenoid (CMS) Electromagnetic Calorimeter (ECAL) data acquisition system has been an essential tool for the detector commissioning.

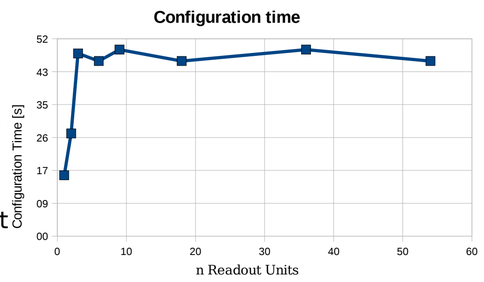
The development of the system started with the detector construction and has constantly accompanied it.

All the detector components have been tested employing the DAQ system as part of the integration process and have been carefully verified during the in-situ installation. A large fraction of the detector has been pre-calibrated with electron beams and all the Barrel using cosmic rays.

Over time, the system has been optimized, made more robust and has always been operated with very good efficiency. So far, it has accumulated more than 1600 hours of operation in test-beams and more than 3000 in situ.




Accumulated time of in situ operation of the ECAL DAQ system.

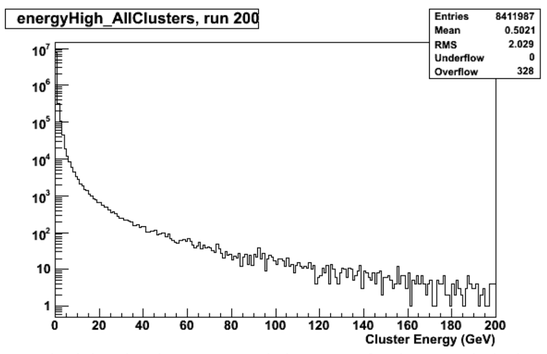



Time needed for the configuration of the ECAL DAQ as a function of the number of employed readout units.

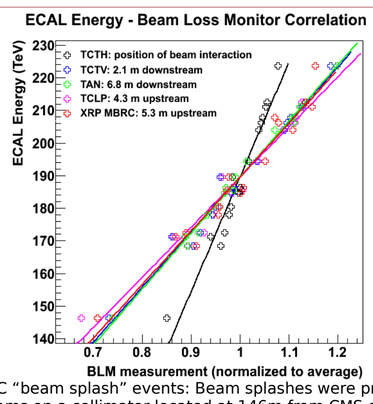
## In situ operation with cosmic rays and first LHC beams

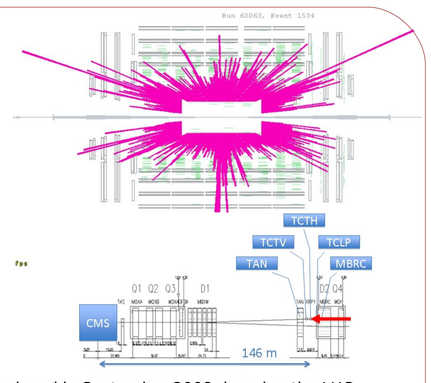
Since September 2008, the CMS detector has been closed and has been operated with the first LHC beams as well as with cosmic rays and a 3.8T magnetic field.

The acquired data has been extremely important for the commissioning of the detector. Overall, more than 350M cosmic ray events have been accumulated during 2008.

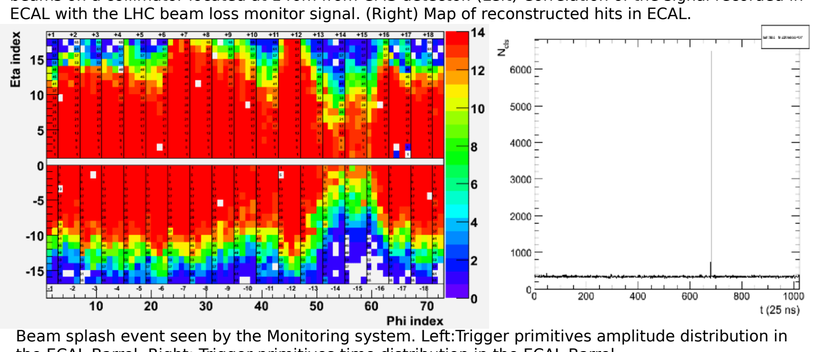



The acquired data has been extremely important for the commissioning of the detector. Overall more than 350M cosmic ray events have been accumulated during 2008.




LHC "beam splash" events: Beam splashes were produced in September 2008 dumping the LHC beams on a collimator located at 146m from CMS detector. (Left) Correlation of the signal recorded in ECAL with the LHC beam loss monitor signal. (Right) Map of reconstructed hits in ECAL.



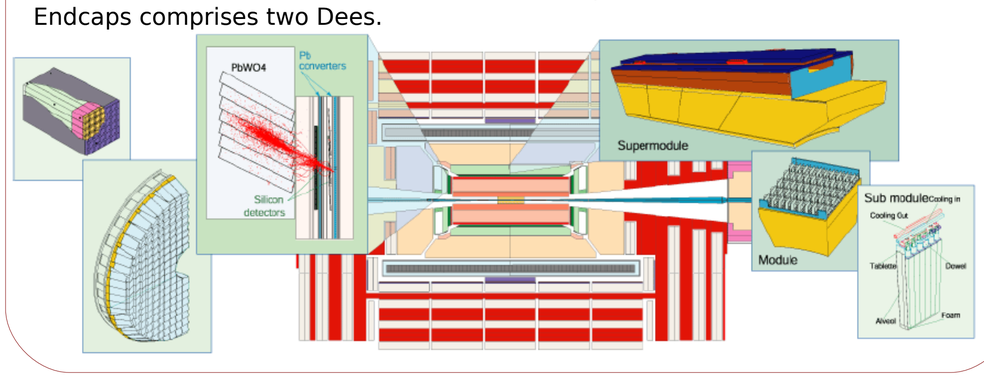

Beam splash event seen by the Monitoring system. Left:Trigger primitives amplitude distribution in the ECAL Barrel. Right: Trigger primitives time distribution in the ECAL Barrel.

## The CMS Electromagnetic calorimeter

The Electromagnetic Calorimeter (ECAL) of the Compact Muon Solenoid (CMS) detector at the CERN Large Hadron Collider (LHC) is a homogeneous crystal calorimeter made of about 76000 Lead Tungstate crystals.

The detector is designed to provide excellent energy and position resolution for electrons and photons in the 1GeV-1TeV energy range.

ECAL is organised in an Barrel and and Endcap part and its mechanical design is modular. The Barrel detector is divided in 36 Supermodules, while each of the Endcaps comprises two Dees.




## The ECAL Trigger and Data Acquisition System

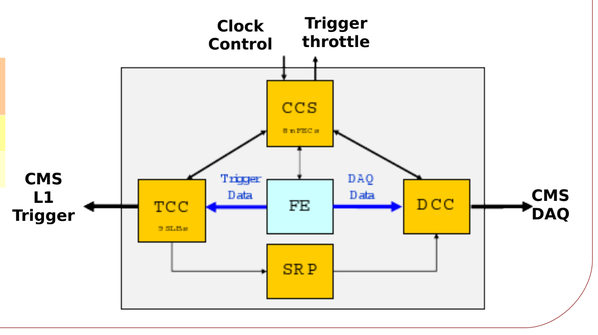
The high granularity of the ECAL design implies an equally high number of readout channels. ECAL information is used both in the CMS Level 1 Trigger, which receives coarse informations on energy deposit (trigger primitives), and the High Level Trigger systems, which uses full granularity data.

The readout system is physically divided in two sections: the on-detector and the off-detector electronics. The first is responsible for the signal digitization and the trigger primitives production. The second is responsible for the finalization of the trigger primitive calculation and for the readout and reduction of the full granularity data.

The off-detector electronics are organised in 54 Readout Units each comprising three type of VME boards: the Clock and Control System (CCS), the Trigger Concentrator Card (TCC) and the Data Concentrator Card (DCC).

Data reduction is achieved using a Selective Readout algorithm based on the classification of the detector in high and low interest regions performed by the Selective Readout Processor (SRP).

| | N of channels | Acquisition rate |
|---|---|---|
| Trigger | 5.5k | 40MHz |
| Readout | 76k | 100kHz |

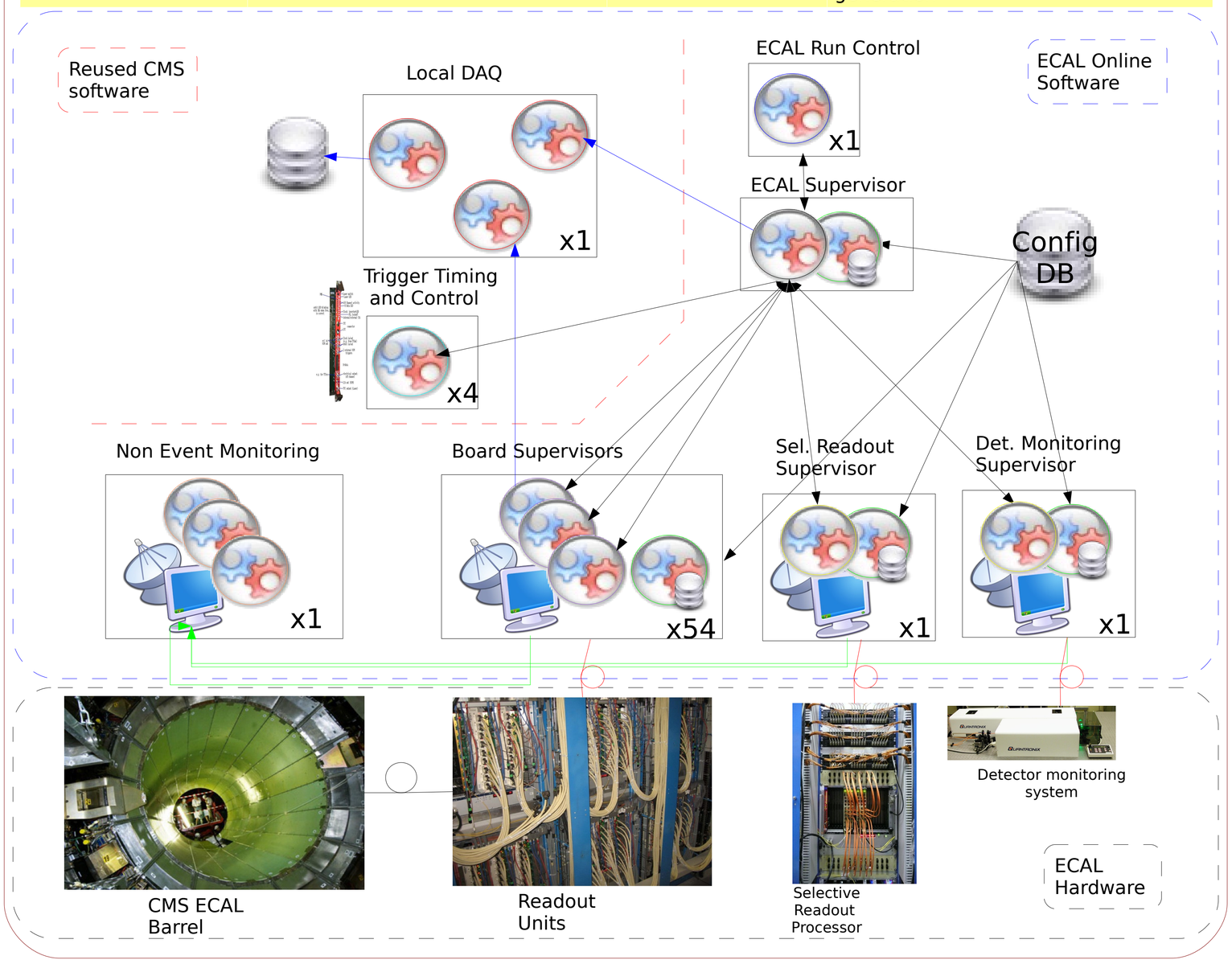



## The ECAL Online Software

The operation of the ECAL Trigger and Data Acquisition system requires the configuration of $10^7$ registers and the monitoring of $10^5$ registers and memories. The ECAL Online Software is the system responsible for the operation of the ECAL detector during data taking.

The system is a web-based distributed system developed in the c++ and Java languages and built on top of the CMS data acquisition and run control frameworks XDAQ and RCMS. The architecture of the system is modular in order to allow good scalability. The main modules of the system and their functions are listed below,

| | | | |
|---|---|---|---|
| ECAL Run Control and ECAL Supervisor | - ECAL Resources configuration<br>- Applications lifecycle handling<br>- Interfacing to external components | Middleware applications | - Interface to database for configuration retrieval<br>- Resource discovery and locking |
| Resource Supervisors | - Configuration of single resources in the system.<br>- Production of monitoring data | Monitoring and alarming system | - Collection, processing and presentation of the monitoring data<br>- Permanent storage of data and alarm generation |




**Acknowledgements**: Financial support from Fundação para a Ciência e a Tecnologia through SFRH/BD/30536/2006 is gratefully acknowledged